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Estimating Fuel Weights of Two Common Shrubs in Colorado Lodgepole Pine Stands[1]

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Abstract

Regression equations were developed for estimating fuel loadings of kinnikinnick and whortleberry shrubs from average height and/or percent crown cover. R^2 for the equations were 0.82 and 0.61, respectively. Guidelines for field application are given.

Keywords: *Arctostaphylos uva-ursi*, *Vaccinium* spp., forest fuel, shrub biomass.

In the southern Rocky Mountains, kinnikinnick (*Arctostaphylos uva-ursi* [L.] Spreng.) and grouse whortleberry/myrtle whortleberry (*Vaccinium scoparium* Leiberg/*V. myrtillus* L.) often dominate the understory of lodgepole pine (*Pinus contorta* Dougl.) stands at low and high elevations, respectively. These shrubs, depending on density, influence the spread of surface fires by partially supporting fine fuels (primarily fallen needle litter and small twigs) in a more optimumly aerated fuel bed than would form otherwise (Fahnestock 1976, Lawson 1972, Muraro 1964). In addition, once the preheating requirements of these shrubs is overcome, they contribute to combustion. A description of fuel weight (shrub biomass) is necessary to document the influence of these two species on potential fire behavior.

Shrub fuel quantities can be described by either (1) collecting material in the field and weighing it, or (2) predicting, which requires known relationships between weight and vegetative descriptors. Sampling techniques that involve clipping, drying, and weighing are time-consuming and tedious. Brown and Marsden (1976) recently formulated a regression equation using percentage of ground covered for estimating kinnikinnick fuel weights in the northern Rocky Mountains. Brown (1976) has also developed a linear regression equation for determining the total aboveground biomass of grouse whortleberry, a species with numerous fine stems. Brown (1976) felt that a technique using percent cover and height (Bentley et al. 1970) would probably be most efficient.

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This Note presents a regional adaptation of the Brown and Marsden (1976) methodology for use in estimating kinnikinnick and whortleberry fuel weights. The work reported here resulted from a broader study to investigate relationships between downed woody fuel and forest floor loadings/depths, and stand structure/site characteristics in natural, even-aged lodgepole pine stands of the Colorado East Front Range (Alexander 1978).

Methods

Fuel sampling in 15 lodgepole pine stands where the understory was dominated by one of the two shrubs (10 kinnikinnick, 5 whortleberry stands) provided for a variety of stand and site conditions. Percent cover, average height, and weight were measured on a minimum of ten 2-square-foot quadrats that were systematically located at fixed intervals. The quadrats were delineated by a 1- x 2-foot frame. The field sampling techniques used were those developed by Brown[3]. In each quadrat, percent cover defined as the vertical project of plant area was sight-gaged and assigned a percent coverage class code: 1 = 0-5%; 2 = 6-20%; 3 = 21-40%; 4 = 41-60%; 5 = 61-80%; 6 = 81-95%; 7 = 96-100%. Midpoint values were treated as continuous independent variable quantities in the data analysis. Height was measured to the nearest inch from the forest floor to an estimated average plant top (Brown and Marsden 1976). Living and dead stem (all <0.25 inch in diameter for both shrub species) and leaf material above the forest floor within a vertical projection of the quadrat frame was clipped, oven dried at 100°C for 24 hours, and weighed to 0.01 gram.

[3]*Brown, James K. 1974. Fuel and vegetation inventory procedures—White Cap Study. Unpublished report on file with the USDA For. Serv., Intermt. For. and Range Exp. Stn., North. For. Fire Lab., Res. Work Unit FS-INT-2104, Missoula, Mont. 11 p.*

Data Analysis and Results

The average height of kinnikinnick seldom exceeded two inches so shrub height was disregarded as an independent variable. A least squares regression using percent cover accounted for 73% of the total variation in the data. A second degree polynomial regression yielded a better fit with an R^2 of 0.82. The resulting equation and pertinent statistics are contained in table 1.

As a basis for selecting the most statistically significant equation for estimating whortleberry loading, a matrix of simple correlation coefficients (r) was constructed between the following independent variable sets: cover, cover squared, height, height squared, cover and height, cover and height squared, cover squared and height, cover × height, cover × height squared, and cover squared × height. Intercorrelation between independent variable sets was checked for significant relationships. This resulted in the following satisfactory sets with their respective r versus weight:

Independent Variable Set	r
cover	0.51
cover squared	.47
height	.71
height squared	.74
cover × height	.78
cover × height squared	.79
cover squared × height	.71

The best regression selected used the product of cover × height; it accounted for 61% of the total variation in the data (table 1).

Discussion

The equations presented in table 1 exhibited F ratios significant at the 99.5% level. The expected variation of weight within a coverage class caused a poorer fit. The occurrence of minor herbaceous vegetation also contributed to some of the variation.

Table 1.—Equations for estimating shrub loading (Y), tons/acre, from cover (X_1), %, and plant height (X_2), inches.

Shrub species	Equation	R^2	F	SE	$\bar{Y}$
Kinnikinnick	$Y = 0.00219\ X_1 + 0.00014\ X_1^2$	0.82	268.104	0.085	0.109
Whortleberry	$Y = -0.06077 + 0.00180\ X_1X_2$	0.61	106.802	0.253	0.508

Brown and Marsden (1976) developed a second degree polynomial equation for estimating kinnikinnick fuel weights in western Montana and northern Idaho with an R^2 of 0.91. In their study, however, the average plant height was always greater than 4 inches, and pinegrass (*Calamagrostis rubescens* Buck.) was present in 84% of the cases as a major component. These two points probably account for the difference in the coefficients of the two equations. Thus, the equation presented in table 1 with an R^2 of 0.82 is recommended for Colorado conditions.

Of the 25 shrub species for which Brown (1976) developed linear regressions for estimating total aboveground biomass, all exhibited R^2 values of 0.84 or better except for two species. Grouse whortleberry was one of these, having an R^2 of 0.62. Considering the degree of precision versus time allocated, the percent cover × average height technique presented here (R^2 of 0.61) versus a tally of basal stems seems justified.

Conclusions

The regression equations developed here provide a convenient, nondestructive, relatively precise method for estimating shrub fuel weights of kinnikinnick and whortleberry. These weights can be used not only in modeling potential fire behavior, but also for such other purposes as estimating standing herbage crop and biomass development following fire. The equations may be less accurate for stands not dominated (<75% coverage) by one of the two shrubs.

Sampling Suggestions

Dry weights of the two shrubs per unit area can be determined in conjunction with other resource inventories. Rectangular or circular quadrats (2.0 ft^2 area) should be systematically spaced within the stand and ocular estimates made of percent cover (to the nearest 5% or 10%). For whortleberry, it will be necessary to determine average shrub height within the quadrat. Loadings can be determined by calculating the mean percent cover and height in the case of whortleberry, and using the appropriate equation or the nomogram (fig. 1). In addition, the amount of dead material could also be determined in the field by ocular estimating the percentage of the total weight. In terms of stand sampling intensities, at least 30 quadrats per acre will be needed to hold sampling errors to 25% for kinnikinnick and 10 per acre for whortleberry.

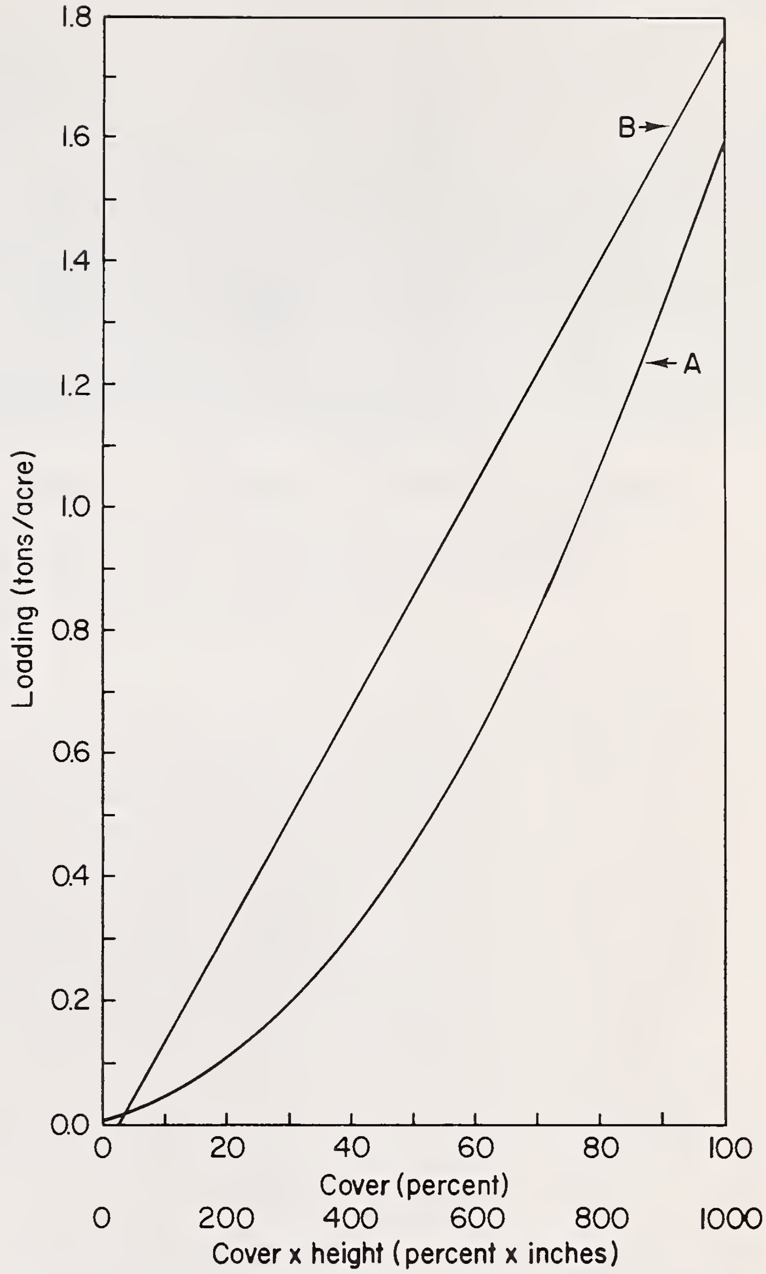

Figure 1.—Loading of kinnikinnick as a function of percent cover (A). Loading of whortleberry as a function of cover times height (B).

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